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(54) Optical switching

(57) A portion of an input optical signal (S) is deflected to a respective output channel (4) by a holographic grating written in a photorefractive material by means of a write control beam (W) and an address optical signal output from means (fibre 5) associated with the output channel (4). The grating is erased using the writing beam (W) alone. Similarly an address signal from fibre 5′ and the write beam W produces a respective holographic grating which causes a part of the input signal (S) to be deflected to fibre 4′. Thus there is provided an optical switch in which the output channel is "self-addressing".

Fig. 1.

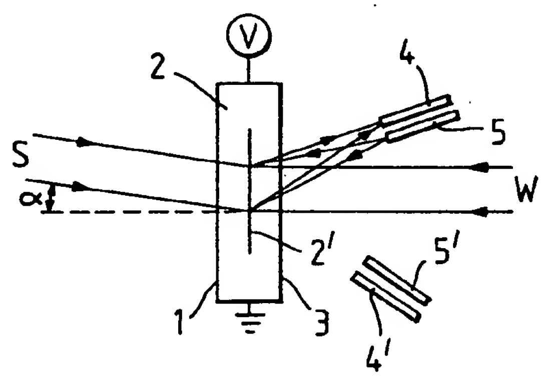

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Fig. 1.

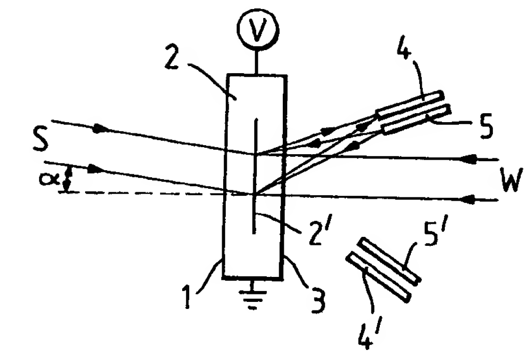


Fig. 2.

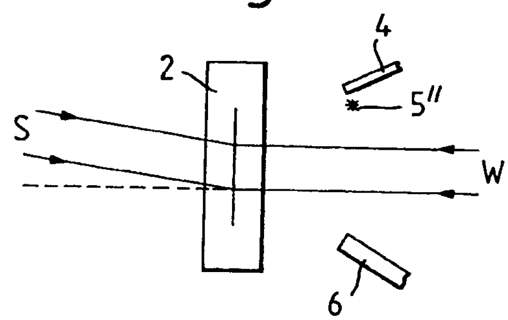
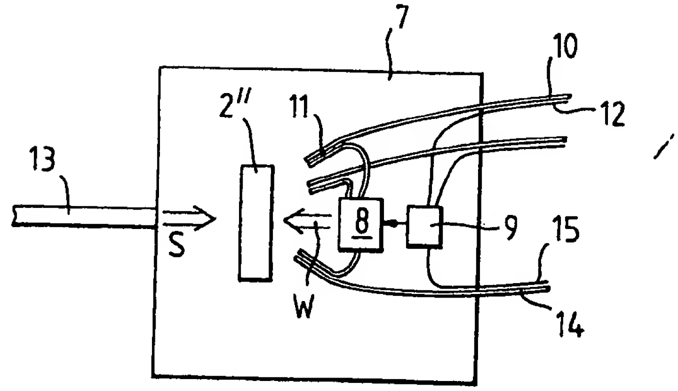


Fig. 3.



SPECIFICATION

Optical switching

This invention relates to optical switching and in particular to the switching of an optical signal in response to another optical signal.

According to one aspect of the present invention there is provided an optical switch comprising an input channel, one or more output channels and means for deflecting a portion of an input optical signal applied to said input channel to a respective output channel in response to an optical address signal associated with said respective output channel.

According to another aspect of the present invention there is provided a method of switching an input optical signal to a respective output channel in response to an optical address signal associated with said respective output channel, including the steps of forming a holographic grating in a photorefractive material in response to said optical address signal and a write optical signal directed towards said material from one side thereof and deflecting a portion of said input optical signal, which is directed towards said material from the opposite side thereof, by said holographic grating towards said respective output channel.

Embodiments of the invention will now be described with reference to the accompanying drawings, in which:—

Figure 1 illustrates schematically a basic system for switching a portion of a signal beam to an optical fibre in response to a corresponding address optical signal.

Figure 2 illustrates schematically variations to the basic system of Fig. 1, and

Figure 3 illustrates schematically a one input/three output optical switch.

In Fig. 1 there is illustrated a signal optical beam S which is collimated and incident on one face 1 of a photorefractive crystal or material 2 at an angle α to the perpendicular to the one face. Another collimated optical beam W, which is termed a writing beam for reasons which will be apparent hereinafter, is incident on the opposite face 3 of the photorefractive material 2 perpendicularly thereto. Also illustrated are a pair of optical fibres 4 and 5 disposed at suitable angular positions relative to the writing beam W.

In order to cause a portion of the signal optical beam S to be deflected to optical fibre 4 an address optical beam is output from fibre 5 and directed towards the photorefractive material 2. If the address optical beam from fibre 5 is of the same wavelength and temporally coherent with writing beam W, and the two beams interfere within the photorefractive material 2, then refractive index variations are induced in the material 2, forming a holographic grating indicated by line 2′ therein. The effect of this grating is to cause deflection of part of the incident signal beam S into the fibre 4, which must obviously be suitably positioned for the signal beam portion to be launched thereinto. Typically only of the order of 1% of the signal beam is deflected. By applying a transverse electric field (as indicated by voltage source V) of the order of 1 to 6kv per cm to the material 2 an increased amount of the signal beam may be deflected, but the amount will still be small, for example 3%. If the address signal is from fibre 5′ then part of the input signal S can be deflected to fibre 4′ by the corresponding grating written by address signal from fibre 5′ and the write beam W.

Typically for the visible region of the spectrum the write beam W may be green, for example from an argon ion laser (λ=488nm), and the signal beam S may be red, for example from a helium-neon laser (λ=633nm).

In order for the write beam W and the address beam from fibre 5 to be temporally coherent they may be produced by the same optical source (not shown in Fig. 1). The address beam and write beam W are preferably pulsed in order to overcome problems arising from vibration/mechanical instabilities, however the same problem does not occur during read out of the signal beam S by fibre 4.

If the signal beam S were of the same wavelength as the write beam W then angle $\alpha\alpha$ would be zero and the beams would be exactly opposite one another. To avoid erasure of the grating in this case the signal beam S should be of lower energy than the write beam. As a result of the signal beam S is preferably at an angle α as illustrated in Fig. 1 and of a longer wavelength. The longer the wavelength the greater the angle of deflection produced by the grating. With different write and signal wavelengths the grating can be "set up" in the photorefractive material by the write and address beams which are then switched off. When a signal beam arrives it will be deflected and not cause the grating to be cleared.

In the case of an address fibre 5 and a receive fibre 4 as illustrated in Fig. 1, fibre 5 is preferably single mode in order to produce a Gaussian beam, whereas fibre 4 is preferably multimode thus presenting a larger aperture to receive the deflected portion of signal beam S. The address fibre 5 may actually be replaced by an aperture to produce a point light source as indicated in Fig. 2 and 5″. Alternatively the fibres 4 and 5 of Fig. 1 may be replaced by a single multimode fibre as indicated by fibre 6 in Fig. 2.

In order to erase the grating and thus cancel deflection of the signal beam the pulsed writing beam W alone is employed.

Typically the photorefractive material may be comprised by $Bi_{12}SiO_{20}$ or $Bi_{12}GeO_{20}$ for operation in the visible region of the spectrum. Alternatively it may be comprised by Ge

doped InP or Cr doped GaAs for operation in the infra-red region of the spectrum.

For efficient operation the photorefractive material and at least the output optical fibre ends will need to be disposed in a lightproof container and rigidly mounted therein. The write beam source may also be disposed therein. The alignment of the signal beam with the crystal/material 2 is critical hence the input to the container for the signal beam may be comprised by an input optical fibre permanently coupled to a face of the container.

Whereas Fig. 1 only indicates two pairs of optical fibres 4 and 5 and 4′ and 5′, more than two pairs may be employed, that is portions of the signal beam may be deflected to any of a number of different outputs according to the grating set up in the photorefractive material.

Fig. 3 illustrates schematically a three output switch. Within lightproof container 7 is disposed a photorefractive material 2″, three pairs of optical fibres (one address fibre and one output fibre per pair), a laser source 8 for the write and address beams together with control means 9 for activating the laser source as appropriate for writing/erasing and controlling which address beam is activated in response to a corresponding externally applied "command" input which may for example be electrical, optical, ultrasonic etc. For example in order to deflect part of the signal beam S supplied on fibre 13 to fibre 10 which constitutes one output of the switch, a signal of some form is supplied such as via line 12 whereby the write beam W is switched on together with sending an address beam via fibre 11 to write the corresponding grating. When the deflected signal beam is no longer required on output fibre 10, a corresponding "command" signal is supplied such as via line 12 whereby to cause erasure of the grating. A part of the signal beam can then be deflected to another output fibre such as 14 upon receipt of an appropriate "command" signal on line 15.

Such an optical switch in which the output channel is self-addressed and the actual switching is achieved optically may be employed in communications systems or any other systems where an optical signal may be required to be received by any one of a number of "users" in response to a signal from the "user".

CLAIMS

1. An optical switch comprising an input channel, one or more output channels and means for deflecting a portion of an input optical signal applied to said input channel to a respective output channel in response to an optical address signal associated with said respective output channel.

2. An optical switch as claimed in claim 1 wherein said means comprises a photorefractive material and a write optical signal source, said optical address signal associated with said respective output channel and a write optical signal from said source serving to write a holographic grating in said photorefractive material for the deflection of said portion of said input optical signal to said respective output channel.

3. An optical switch as claimed in claim 2 wherein use of said write optical signal alone serves to erase a holographic grating previously written in said photorefractive material.

4. An optical switch as claimed in claim 2 or claim 3 wherein the optical address signal and the write optical signal are of the same wavelength and temporally coherent.

5. An optical switch as claimed in claim 4 wherein the optical address signal and the write optical signal are pulsed.

6. An optical switch as claimed in any one of claims 2 to 5 wherein the input optical signal is of a longer wavelength than the optical address signal and the write optical signal and the input channel is disposed whereby the input optical signal is incident on a face of the photorefractive material at an angle with respect to a perpendicular to said face.

7. An optical switch as claimed in any one of claims 2 to 6 wherein the or each output channel is comprised by a respective optical fibre and associated with each thereof is a respective address optical fibre via which the optical address signal is transmitted towards the photorefractive material.

8. An optical switch as claimed in any one of claims 2 to 6 wherein the or each output channel is comprised by a multimode optical fibre via which the respective optical address signal is transmitted towards the photorefractive material.

9. An optical switch as claimed in any one of claims 2 to 6 wherein the or each output channel is comprised by a respective optical fibre and associated with each thereof is a respective aperture acting as an optical point source whereby an address optical signal derived from the write optical source can be supplied to the photorefractive material for use in writing a holographic grating.

10. An optical switch as claimed in any one of claims 2 to 9 wherein the photorefractive material is selected from the group consisting of $Bi_{12}SiO_{20}$, $Bi_{12}GeO_{20}$, Fe doped InP and Cr doped GaAs.

11. An optical switch as claimed in any one of claims 2 to 10 including means for the application of an electric field to the photorefractive material substantially transversely to the general direction of optical signal passage therethrough.

12. An optical switch substantially as herein described with reference to Fig. 1, Fig. 2 or Fig. 3 of the accompanying drawings.

13. A method of switching an input optical signal to a respective output channel in

sponse to an optical address signal associated with said respective output channel, including the steps of forming a holographic grating in a photorefractive material in response to said optical address signal and a write optical signal directed towards said material from one side thereof and deflecting a portion of said input optical signal, which is directed towards said material from the opposite side thereof, by said holographic grating towards said respective output channel.

14. A method as claimed in claim 13 including the step of applying an electric field to said photorefractive material transversely to the general direction of optical signal passage therethrough between said sides thereof.

15. A method as claimed in claim 13 or claim 14 including the step of erasing the holographic grating produced with the aid of one respective optical address signal by directing the write optical signal alone towards said one side of the photorefractive material and forming another holographic grating in the photorefractive material in response to the optical address signal associated with another output channel and said write optical signal, whereby to deflect a portion of said input optical signal to said other output channel.

16. A method of switching an input optical signal substantially as herein described with reference to Fig. 1, Fig. 2 or Fig. 3 of the accompanying drawings.

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